Ontario

Municipal Affairs and Housing | Ministry of Energy

A Housing Energy Management Program Report

Energy
Ontario

HIGH EFFICIENCY RESIDENTIAL CONDENSING GAS FORCED AIR AND HIGH EFFICIENCY PULSE BOILERS

FIELD EVALUATION "INSTALLATION REPORT" (INTERIM REPORT)

REPORT No. 5A

Undertaken jointly by the Ontario Ministries of Municipal Affairs and Housing and Energy under the Housing Energy Management Program (H.E.M.P.)

Prepared for
Ontario Ministry of Municipal Affairs and Housing
Technical Services Division
Research and Development Section

by

NORTHERN AND CENTRAL GAS CORPORATION LIMITED

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INTRODUCTION

Discussions held between the Ministry of Municipal Affairs and Housing and Northern and Central Gas Corporation Limited in 1981, highlighted areas of common interest in the field of high efficiency boilers and furnaces.

From these discussions, a field testing program on high efficiency water boilers and forced air furnaces was arranged. Such a test would provide performance information which would be of significant value in promoting energy conservation.

Four locations were chosen for this study. Two of these test sites would compare hot water boiler systems, while the other two would be forced air systems.

The installations were funded by the Ministry of Energy through the Ministry of Municipal Affairs & Housing. Northern and Central Gas Corporation Limited arranged for and supervised the installations as well as monitoring of the equipment.

The field evaluation of these installations will be carried out from January, 1982 through 1982 - 1983 heating season to generate the performance and operating data.

This report contains information on the equipment under test, monitoring instrumentation, building test site data, installation and costs at selected sites.

INSTALLATION OVERVIEW

Four different locations were chosen for the test sites. These various locations provide an excellent opportunity to compare different types of heating equipment.

The high efficiency units that were used in these comparisons have various advantages. These units eliminate the use of the conventional flue systems. They work on the spark to pilot principal. An electronic ignition lights the pilot. The pilot then lights the burner as in a conventional furnace.

Condensate is removed from the exhaust pipe by a plastic drain.

The first installation is a comparison with a high efficiency hot water pulse condensate type boiler and a coal designed hot water boiler converted to natural gas.

The second installation is a comparison with a high efficiency warm-air condensing gas furnace and a conventional warm-air oil furnace.

The third installation is a comparison with a high efficiency warm-air condensing gas furnace and a conventional warm-air gas furnace.

The fourth installation is a comparison with a high efficiency hot water pulse condensate boiler and a hot water oil heating steel boiler.

All the equipment has been installed in parallel and will be monitored with an elapsed time recorder and an event couter. In order to monitor complete gas and oil consumptions, gas meters were installed on the gas furnace supply line, and oil flow meters on the oil furnace supply lines.

The test equipment will be alternated on a weekly basis with the existing equipment. This should provide for an accurate monitoring of unit cycle events, and fuel consumption which will be compared to the degree day readings obtained from the atmospheric weather stations of Environment Canada.

SITE I

SEC. 1.0. - JANE STREET, NORTH BAY, ONTARIO

This test site is a detached, frame construction, brick veneer and aluminun siding, two storey residence of approximately 141 sq. meters living area. The house is of a fairly tight construction, except for the basement and has R-24 insulation in the ceiling and R-12 in house walls. There is no insulation in the basement walls. Windows and doors are stormed. This house is situated at the bottom of a hill which causes some down draft problems with conventional furnaces in severely cold weather. The residence is shown in figure I, II, III, a schematic diagram of the elctrical wiring on figure IV and information on the residence in table I.

This installation consists of a hot water pulse condensate type high efficiency boiler and a coal designed hot water boiler converted to natural gas. The installation is now completed and apparently working well. In the planning stages, it was decided to completely isolate the two boilers in order to prevent circulation through one boiler while the other was being monitored. This was especially important in the coal designed boiler since its large heating surface could distort the monitoring of the pulse boiler. It was also decided that two switching relays would be required in order to accomodate the elapse time recorder and event counter. These relays were required in order to energize the 110 volt power circuit every time an electrical load took place on the 24 volt circuit operating thermostats and gas valves on both boiler systems. It is not known, at this time, if 24 volt elapse time meters or event counters are available. In any event, we felt the contingency costs involved with two switching relays would expedite matters regarding the project. The actual installation on both boilers was done quickly and efficiently without any meaningful incident. The furnace flue is isolated when the pulse unit is in operation

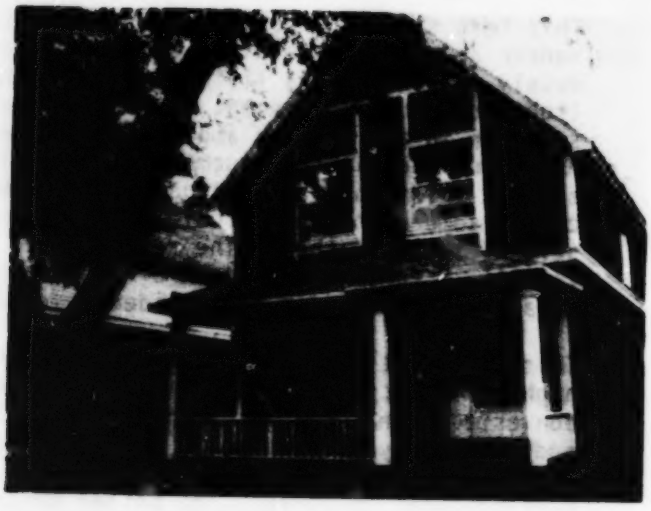
Start-up procedures revealed the following problems:

a) Quick cycling resulted due to the number of controls on the 24 volt circuit. This problem was easily corrected by adjusting the heat anticipator on the thermostat.

b) The pulse boiler noise level proved to be about the same noise level as a standard oil burner, this noise telescoped into the building through the solid gas pipe. This was substantially reduced by installing a standard gas range flex fitting. After several days of operation, the noise level of the pulse combustion boiler increased dramatically. Consultation with the manufacturer suggested a defective muffler which resulted in a new boiler being shipped. This new boiler has replaced the defective one. It is not always necessary to replace a boiler with a defective muffler problem. Since this boiler was to be used as a test, the manufacturer felt that replacing the boiler was the best way to proceed. The noise level is now at an acceptable level.

FIGURE I

SEC. 1.1.



SEC. 1.2.

FIGURE II

Basement Floor Plan
Jane Street, North Bay

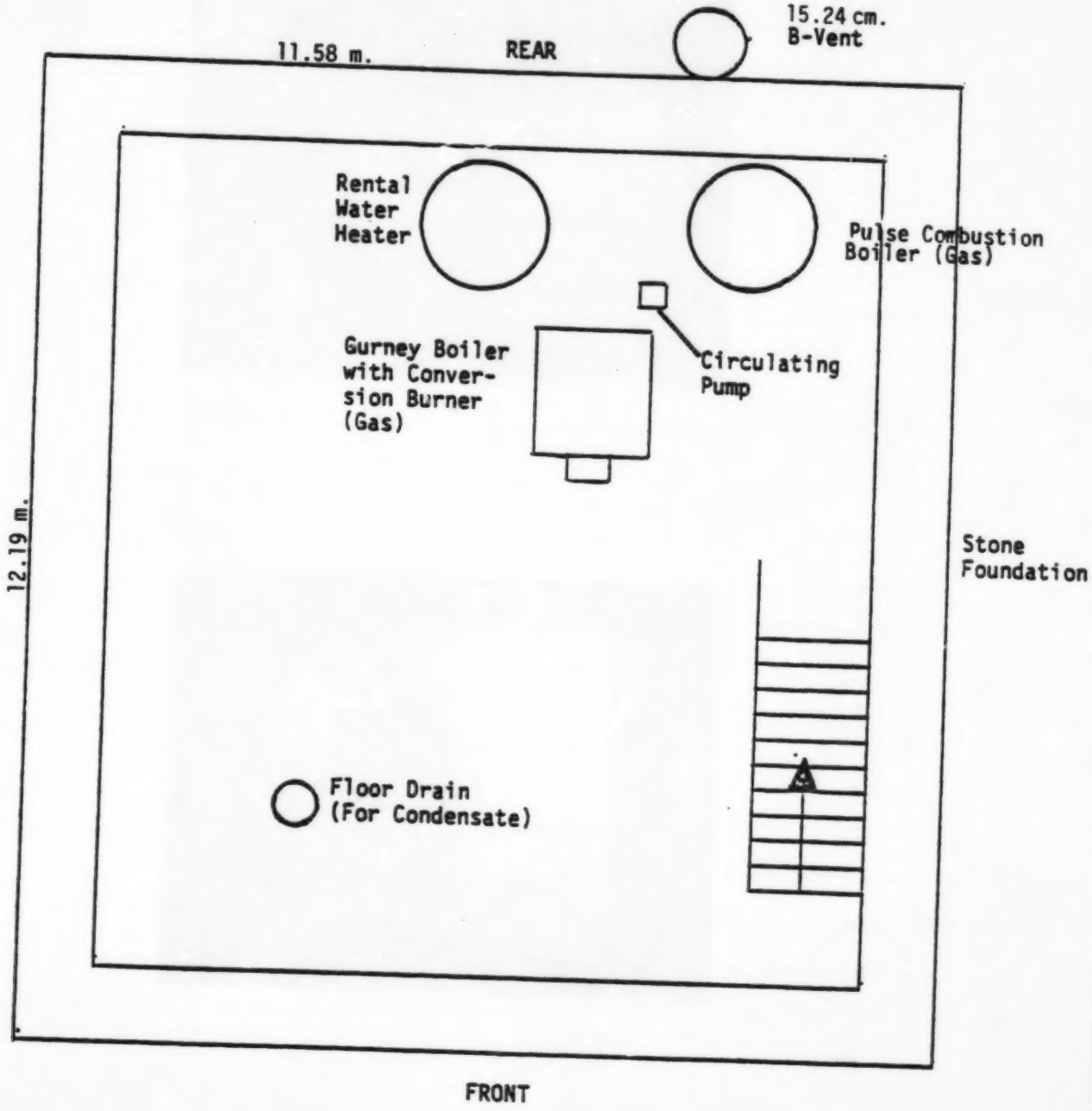
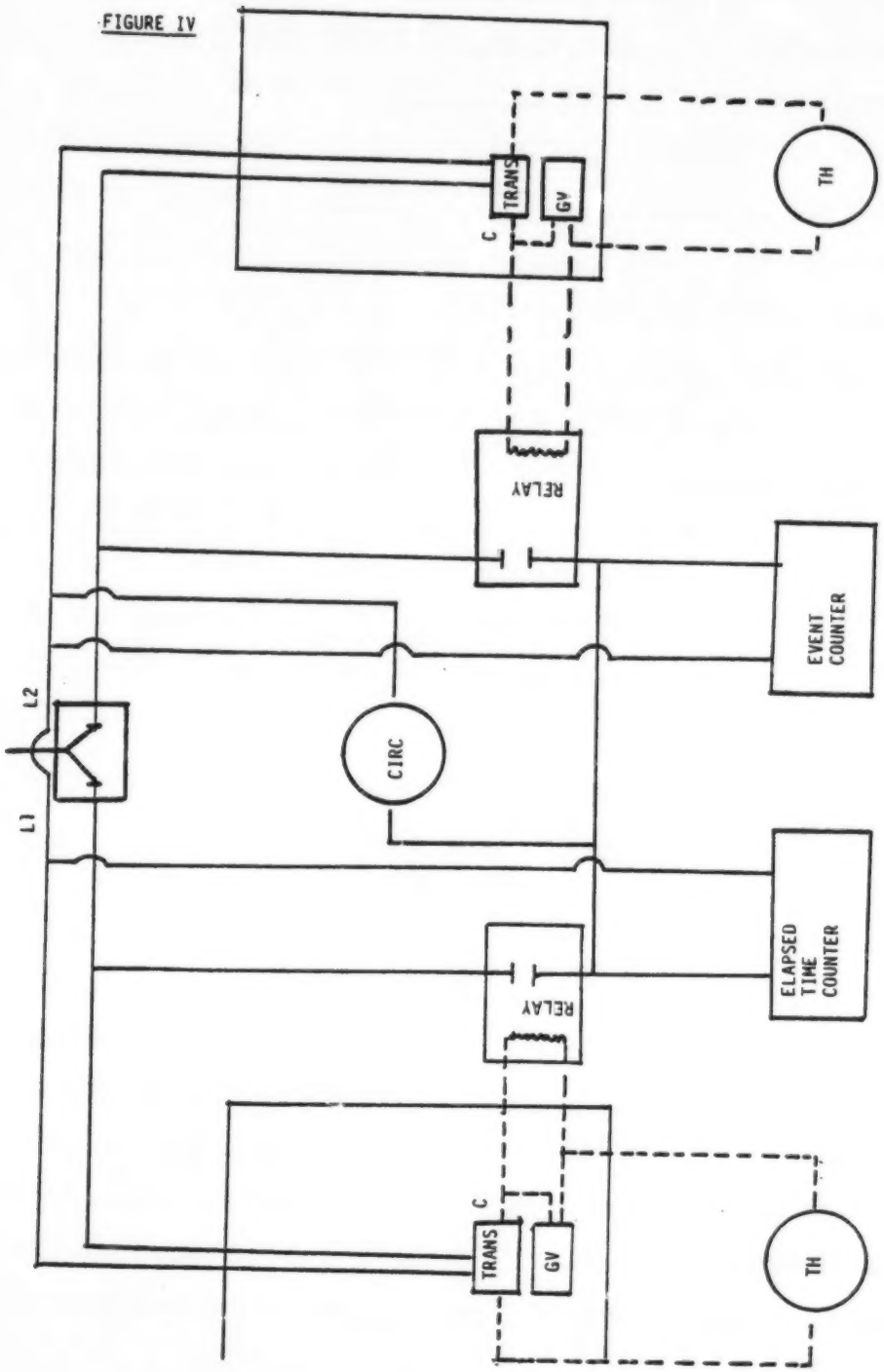


FIGURE III

SEC. 1.3.

SEC. 1.4.

FIGURE IV



751 Jane St., North Bay

SEC. 1.5. HOMEOWNER QUESTIONNAIRE TABLE I

GENERAL INFORMATION

Name of occupant Company Employee

Installation address Jane Street, North Bay, Ontario

Single Family Residence? Yes Multiple? _____

Approx. age of structure 60 Years How long have you resided? 3 Years

No of occupants 4 Adults 2 How may are employed 2

If two or more, which hours 8 A.M. to 5 P.M.

What indoor temperatures do you maintain:

While at work 18°C Hours 7:30 A.M. to 5:15 P.M.

Daytime 18°C Hours 7:30 A.M. to 5:15 P.M.

Nightime 19°C Hours 11:00 P.M. to 6:00 A.M.

While at Home 20°C Hours 5:15 P.M. to 11:00 P.M.
6:00 A.M. to 7:30 P.M.

STRUCTURE

Do you have a basement Yes Is it heated No

Number of stories 2

Type of construction (Brick or Frame) Main floor brick, Second Floor frame

Does it have storm windows Yes Storm doors Yes

Is it insulated Yes Existing insulation R-value: Walls R-12,

Roof R-24, Basement None.

Was any insulation installed recently No If so, when _____,

Where, and thickness _____ Type _____

In your opinion, is building of tight construction Except for basement

No. of basement windows 3 Do they close tightly No

Is the door to the basement normally closed Yes

No of exhaust fans: Kitchen None Bathroom None Other None

Where is thermostat located (room) L R Inside or Outside wall Inside

Does this house have a fireplace No Does it have a good damper _____

....Cont'd.

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SEC. 1.6. HOMEOWNER'S QUESTIONAIRE

APPLIANCES

Does this residence have a gas light No

Input or number of mantles _____

Does this residence have an electric or gas range Electric

If gas: Type _____ Location _____

Does this residence have a gas grill No

Hourly inputs _____ How often is it used _____

Does this residence have a gas or electric clothes dryer Electric

If gas: Location _____ Vented to outdoors? _____

Size of vent pipe _____ Hourly input _____

How often is it used _____

Does this residence have a gas fired water heater Yes

Storage capacity 150 Litres / 151.4 Litres Hourly input .934 M3

Size of flue pipe 7.62 cm Does this pipe connect to the same chimney as the heating system. Yes

Does this residence have air conditioning No

Central _____ Window units _____ How many? _____

HEATING SYSTEM

Present Furnace.	Test Furnace.
Model 302-21A	Model A-100
Actual Input 3.76 m^3	Actual Input 2.83 m^3
Actual Output 3.01 m^3	Actual Output 2.49 m^3
Age Boiler - 50 years approx.	Age 3 months
Type of Ignition Pilot	Type of Ignition Electric
Type of Venting B-Vent & Drafthood	Type of Venting ABS Pipe

TEST CHANGES:

SITE II

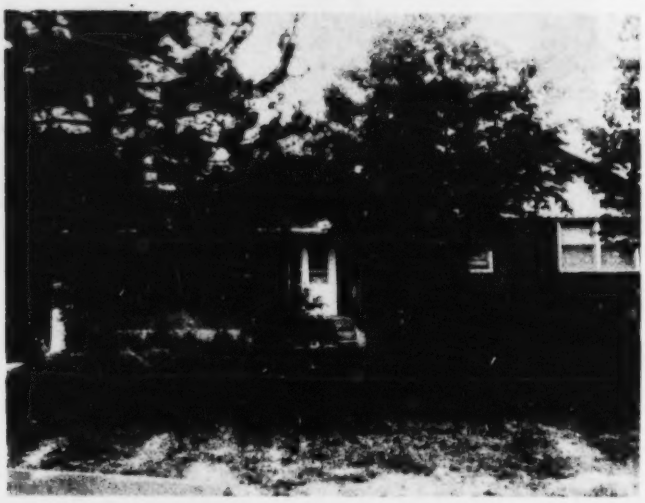
SEC. 2.0. - PINEWOOD ROAD, NORTH BAY, ONTARIO

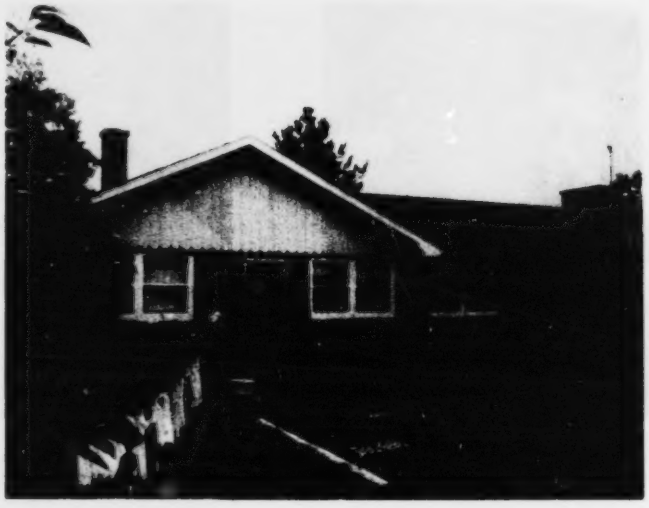
The second test site in North Bay is a detached brick construction, single storey residence of approximately 125 sq. meters of living area. The house is of tight construction had has R-20 insulation in the ceiling and R-12 insulation in the walls and R-12 insulation in the basement walls. Windows and doors are stormed and screened. This home is located in a typical modern residential subdivision. The residence is shown in figures V, VI and VII. A schematic diagram of the electrical wiring on figure VIII provides the rest of the information on the residence.

This installation consists of a high efficiency warm-air condensing gas furnace and a conventional warm-air oil furnace. This installation is now completed and working well. Considerable delay resulted in the fact that the manufacturer required the installer to be fully trained by the Company. A futher two week delay was caused by missing vent fittings in the condensing unit package. A shut-down in the oil unit on the third day proved to be a problem of insufficient oil flow through the oil flow measuring meter. This problem proved to be very difficult to diagnose. However, since then our people have replaced it with another flow meter from our shop and it seems to be working quite well. To prevent flow through the off unit, sheet metal sliders were installed, these are interchangeable and are about 98% effective in isolating one unit from the other.

FIGURE V

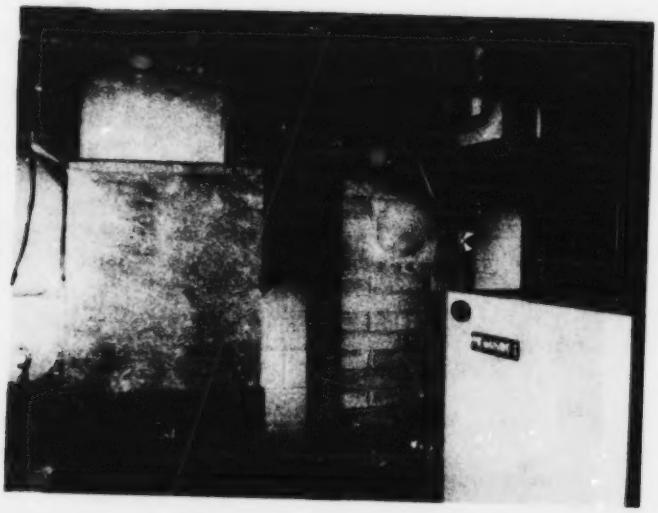
SEC. 2.1.

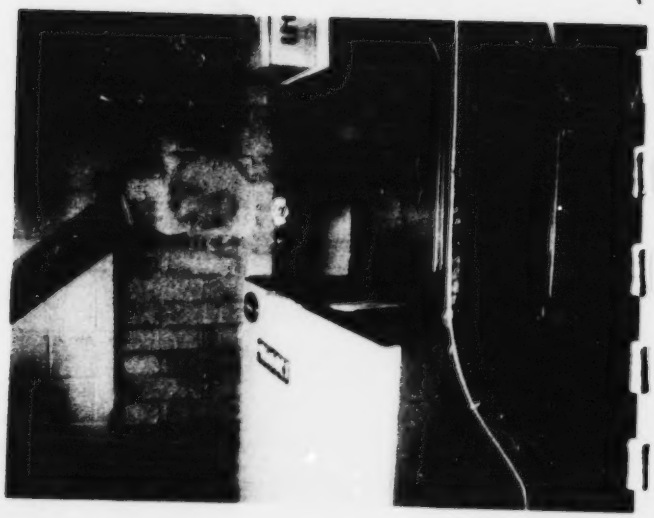




SEC. 2.2.

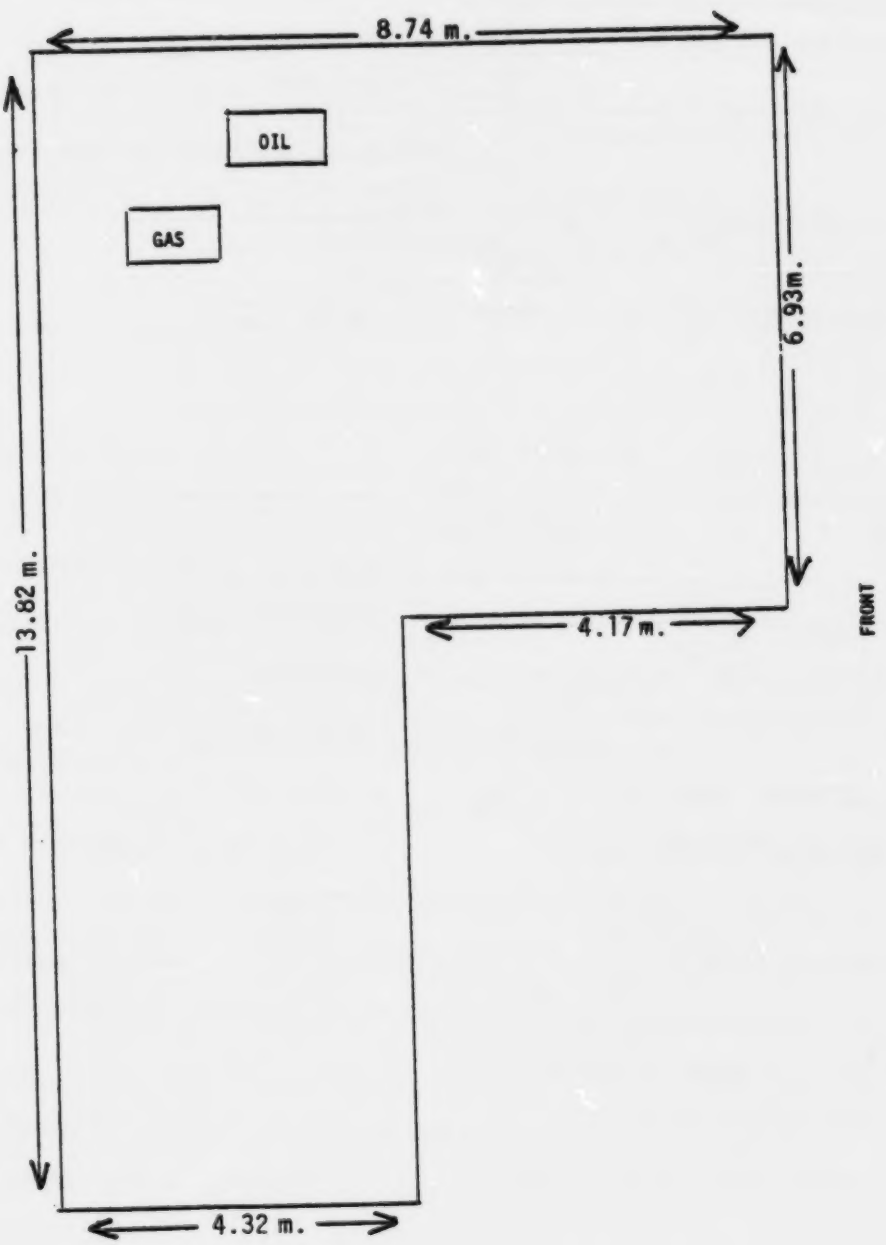
FIGURE VI





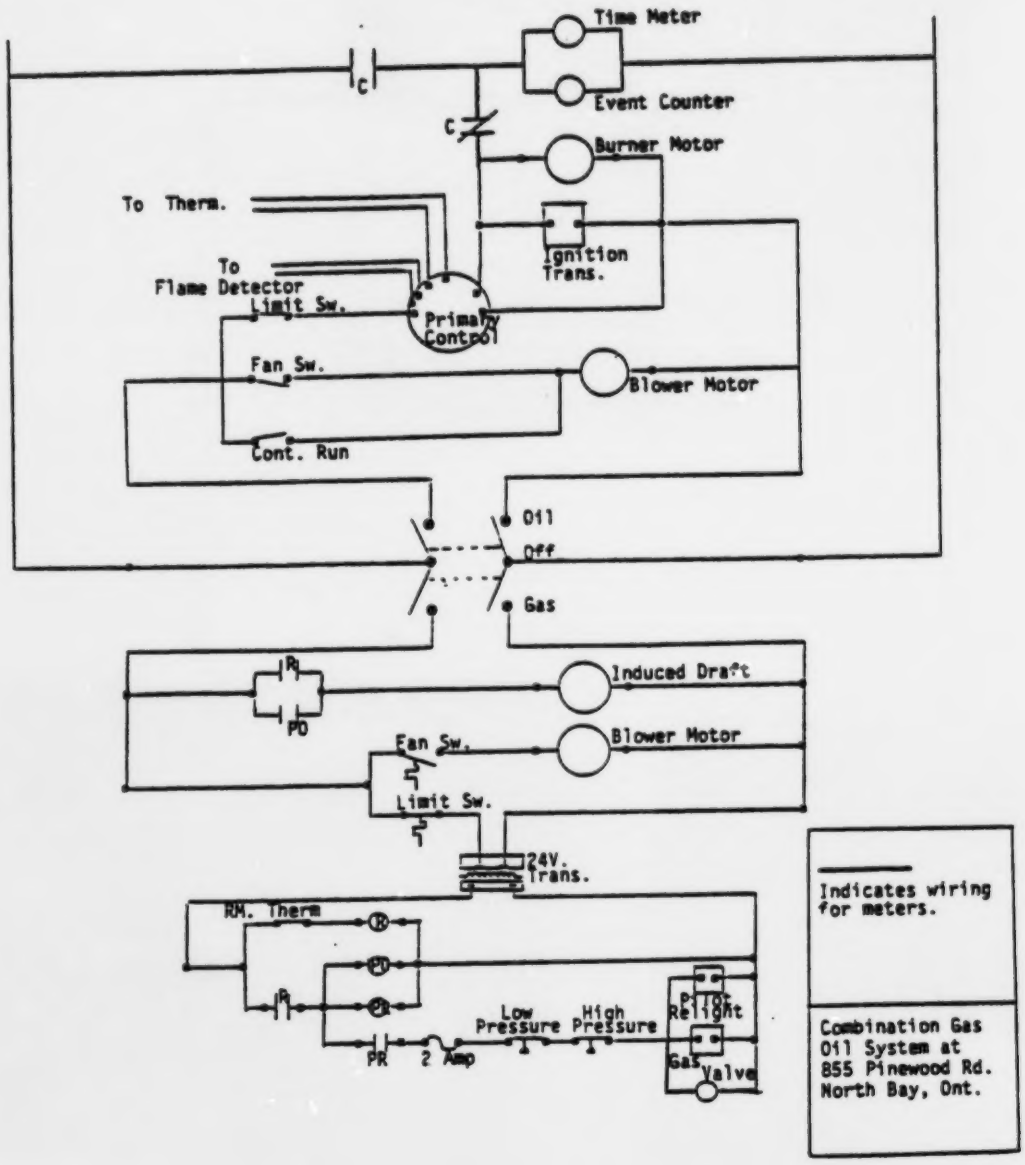
SEC. 2.3.

FIGURE VII



SEC. 2.4.

FIGURE VIII



SEC. 2.5. HOMEOWNER QUESTIONNAIRE TABLE 2

GENERAL INFORMATION

Name of occupant Company Employee

Installation address Pinewood Road, North Bay, Ontario

Single Family Residence? Yes Multiple? _____

Approx. age of structure 25 Years How long have you resided? 8 Months

No of occupants 4 Adults 2 How may are employed 1

If two or more, which hours _____

What indoor temperatures do you maintain:

While at work _____ Hours _____

Daytime 20°C Hours 8:00 A.M. to 11:00 P.M.

Nightime 18°C Hours 11:00 P.M. to 8:00 A.M.

STRUCTURE

Do you have a basement Yes Is it heated Yes

Number of stories One

Type of construction (Brick or Frame) Brick

Does it have storm windows Yes Storm doors Yes

Is it insulated Yes Existing insulation R-value: Walls R-12,

Roof R-20, Basement R-12.

Was any insulation installed recently Yes If so, when January, 1982,

Where, and thickness Basement Type 10.16,Batts-Fiberglass

In your opinion, is building of tight construction Yes

No. of basement windows 8 Do they close tightly Yes

Is the door to the basement normally closed No

No of exhaust fans: Kitchen None Bathroom None Other None

Where is thermostat located (room) L.R. Inside or Outside wall Inside

Does this house have a fireplace Yes Does it have a good damper Yes

....Cont'd.

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HOMEOWNER'S QUESTIONAIRE

SEC. 2.6.

APPLIANCES

Does this residence have a gas light No

Input or number of mantles _____

Does this residence have an electric or gas range Electric

If gas: Type _____ Location _____

Does this residence have a gas grill _____

Hourly inputs _____ How often is it used _____

Does this residence have a gas or electric clothes dryer Electric

If gas: Location _____ Vented to outdoors? _____

Size of vent pipe _____ Hourly input _____

How often is it used _____

Does this residence have a gas fired water heater Yes

Storage capacity 150 Litres 151.4 Litres Hourly input 934 M3

Size of flue pipe 7.62 cm. Does this pipe connect to the same chimney as the heating system. Yes

Does this residence have air conditioning Yes

Central _____ Window units Yes How many? One

HEATING SYSTEM

Present Furnace.	Test Furnace.
Model 90-127-OLB	Model HEG 80
Actual Input 4.5 Litres/hr.	Actual Input 2265 m^3
Actual Output 4.2 Litres /hr.	Actual Output 2110 m^3
Age 4 years	Age 6 months
Type of Ignition Spark	Type of Ignition Spark
Type of Venting Inside Tile Lined	Type of Venting P.V.C.

TEST CHANGES:

SITE III

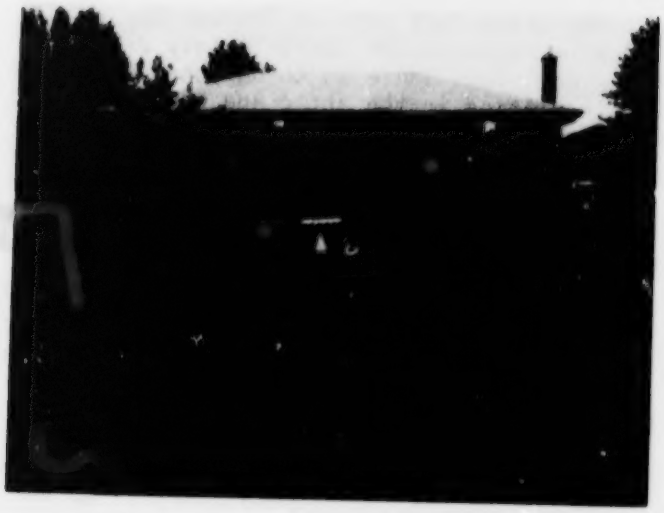
SEC. 3.0. - BROADWAY AVE., THUNDER BAY, ONTARIO

The third test site in Thunder Bay is a detached solid brick bungalow of approximately 212 sq. meters of living area. This house is to be considered air tight with R-24 insulation in the attic and R-12 in the walls and basement. Windows are all double insulated slides with aluminum frames. Exterior doors are solid core wood with aluminum storm doors. This home is located in a flat open area. The residence is shown in figures IX, X, and XI. A schematic diagram of the electrical wiring is shown in figure XII and table 3 represents homeowner description of test site.

This installation consists of a high efficiency warm-air condensing gas furnace and a convention warm-air gas furnace. This installation is now completed and working well. Considerable delay resulted in the fact that the manufacturer required the installer to be fully trained by the Company. The installation proved to be a problem as to the best method of wiring the controls in order to be able to provide the monitoring information in a meaningful manner. In the first wiring set-up, since the elapse time recorder and the event counter were 110 volts, these were wired directly to the fan, and of course, in this manner the recording devices were monitoring the fan activity, and therefore, proved undesirable. As a result of consultation with Earl Wilson Electric Limited of North Bay, it was decided to incorporate two switching relays in order to monitor gas valve activity being the accurate indicator of fuel consumption. To prevent flow through the shut-down unit, both furnace fans come on at the same time. This has not been totally successful since the new furnace fan has a high CFM capacity and therefore when the new unit is on stream there is a slight air flow through the old unit. Isolation dampers cannot be used since they will lower the efficiency of the condensing unit. The flue of the conventional unit is not blocked during operation of the condensing unit.

FIGURE IX

SEC. 3.1.



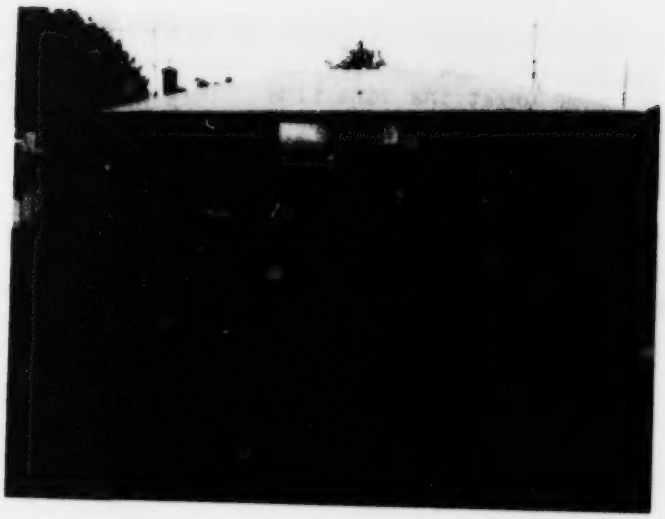


FIGURE X

SEC. 3.2.

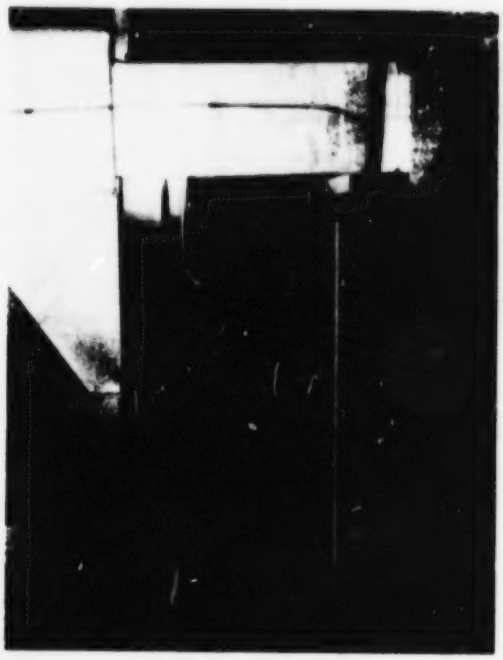
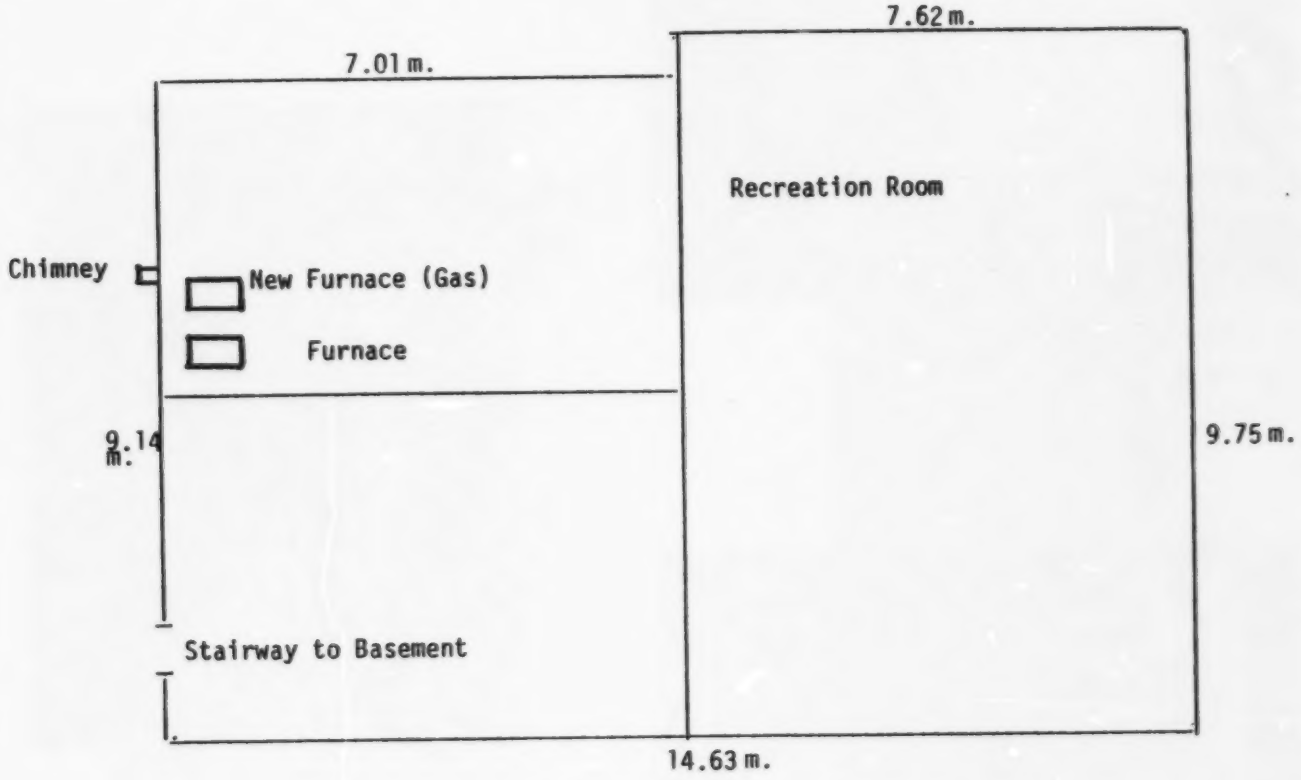


FIGURE XI

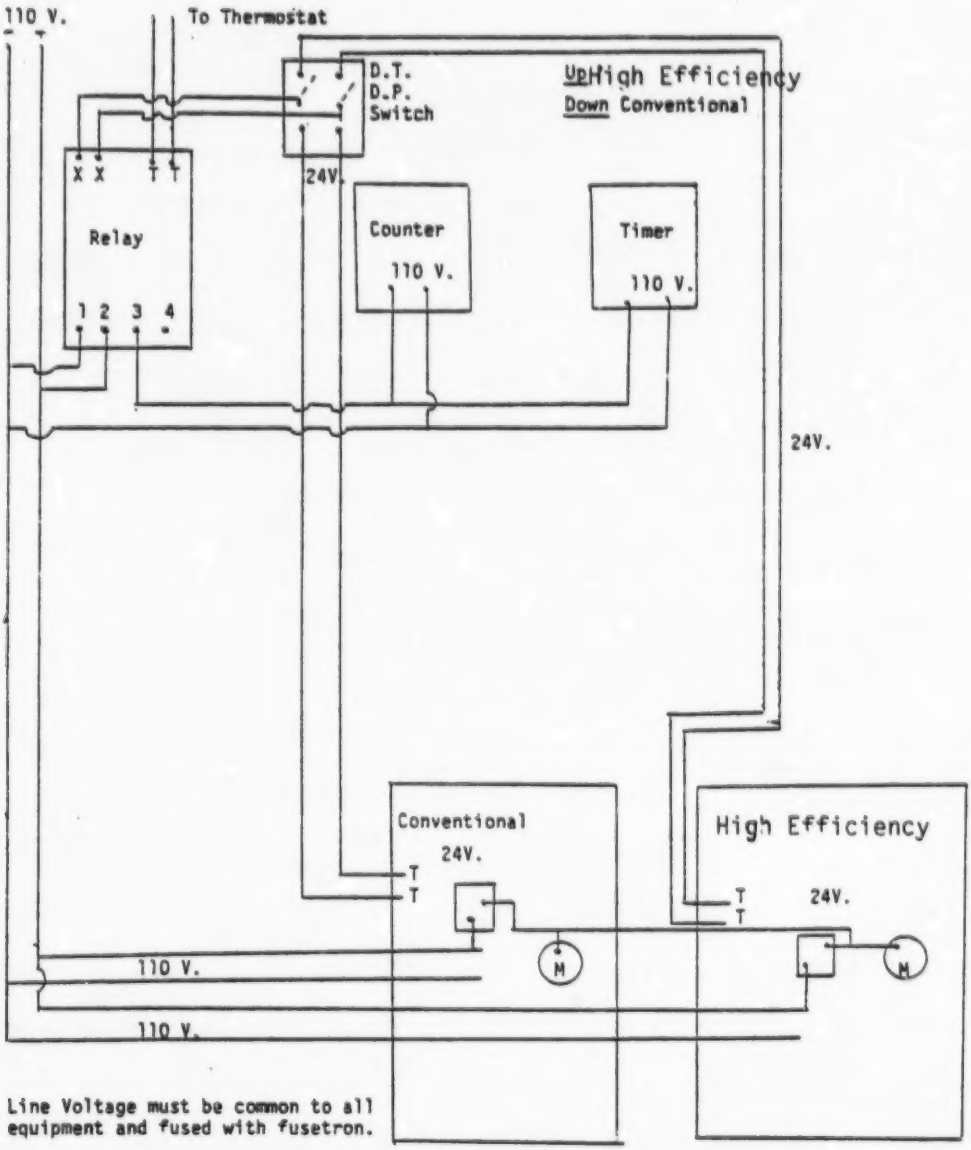


Basement made of 25.4 cm. concrete and insulated with R12 fiberglass insulation.

Broadway Avenue, Thunder Bay, Ont.

SEC. 3.4.

FIGURE XII



Line Voltage must be common to all equipment and fused with fusetron.

Fan Controls in Parallel
All Else remains the same

. Broadway Ave., Thunder Bay, Ont.

SEC. 3.5. HOMEOWNER QUESTIONNAIRE TABLE 3

GENERAL INFORMATION

Name of occupant Company Employee

Installation address Broadway Avenue, Thunder Bay, Ont.

Single Family Residence? Yes Multiple? _____

Approx. age of structure 16 Years How long have you resided? 16 Years

No of occupants 4 Adults 2 How may are employed 1

If two or more, which hours _____

What indoor temperatures do you maintain:

While at work 21.67°C Hours _____

Daytime 21.67°C Hours _____

Nightime 20°C Hours 8 Hours

STRUCTURE

Do you have a basement Yes Is it heated Yes

Number of stories One

Type of construction (Brick or Frame) Brick

Does it have storm windows Yes Storm doors Yes

Is it insulated Yes Existing insulation R-value: Walls R-12

Ceiling R-24, Basement R-12.

Was any insulation installed recently No If so, when _____

Where, and thickness _____ Type _____

In your opinion, is building of tight construction Yes

No. of basement windows Six Do they close tightly Yes

Is the door to the basement normally closed Yes

No of exhaust fans: Kitchen Yes (Internal) Bathroom Yes Other _____

Where is thermostat located (room) Hallway Inside or Outside wall Inside

Does this house have a fireplace No Does it have a good damper _____

....Cont'd.

SEC. 3.6. HOMEOWNER'S QUESTIONAIRE

APPLIANCES

Does this residence have a gas light Yes

Input or number of mantles Two

Does this residence have an electric or gas range Electric

If gas: Type _____ Location _____

Does this residence have a gas grill No

Hourly inputs _____ How often is it used _____

Does this residence have a gas or electric clothes dryer Electric

If gas: Location _____ Vented to outdoors? _____

Size of vent pipe _____ Hourly input _____

How often is it used _____

Does this residence have a gas fired water heater Yes

Storage capacity 150 Litres 151.4 Litres Hourly input .934 M3

Size of flue pipe 10.16 Does this pipe connect to the same chimney as the heating system. Yes

Does this residence have air conditioning No

Central _____ Window units _____ How many? _____

HEATING SYSTEM

Present Furnace.	Test Furnace.
Model AC125	Model HEG80
Actual Input 3537 m^3	Actual Input 2265 m^3
Actual Output 2833 m^3	Actual Output 2110 m^3
Age 14 years	Age 3 months
Type of Ignition Standing Pilot	Type of Ignition Electric
Type of Venting 15.24 cm.	Type of Venting 5.08 P.V.C.

TEST CHANGES:

SITE IV

SEC. 4.0. - OJA STREET, NAUGHTON, SUDBURY, ONTARIO

The fourth site is a two storey framed duplex of approximately 190 sq. meters living area. The home is of average air tightness with R-20 insulation value in the attic, R-12 insulation in the walls and R-12 insulation in the basement walls. Windows are sliding type which are rather loose fitting. Only two of the four doors are stormed. This home is located on the water front of a small lake which subjects the house to above average winds. The second storey of this frame duplex has four sides fully exposed. The first storey has three sides fully exposed and one side partially exposed. The residence is shown in figures XIII, XIV and XV. Table 4 contains the rest of the information on the residence.

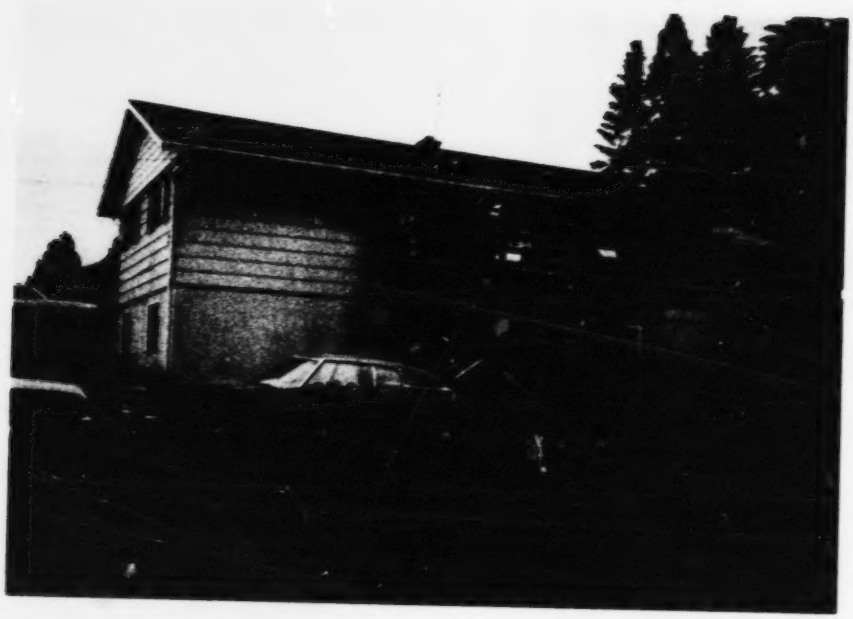
This installation consists of a high efficiency hot water condensate boiler installed in parallel with a hot water oil heating steel boiler. An elapsed time recorder and an event counter serves both boilers. A gas meter is installed on the natural gas furnace supply line and an oil flow meter is installed on the oil furnace supply line in order to provide complete monitoring of field consumption for both appliances.

It was discovered during September, 1982, that the high efficiency boiler was giving false event readings due to the boiler going through more than one purge cycle before igniting. This would cause the boiler to completely shut down and record an event even though it had not actually fired. The manufacturer's representative has been alerted to this problem, and to date has not rectified the situation. As a matter of fact, the boiler has now proven to be so unreliable it is not now being used and we are about to apply severe pressure on the manufacturer to solve the problem.

The problem has since been resolved. The equipment failure was due to a faulty valve.

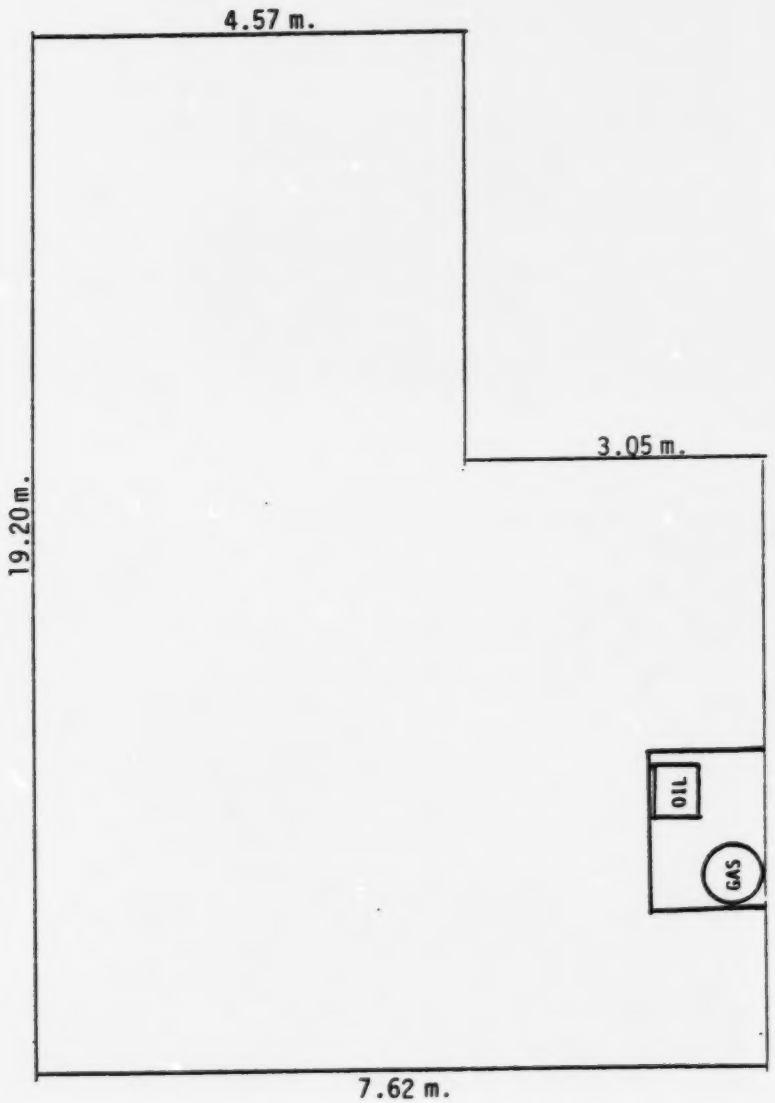
SEC. 4.1.

FIGURE XIII



SEC. 4.2.

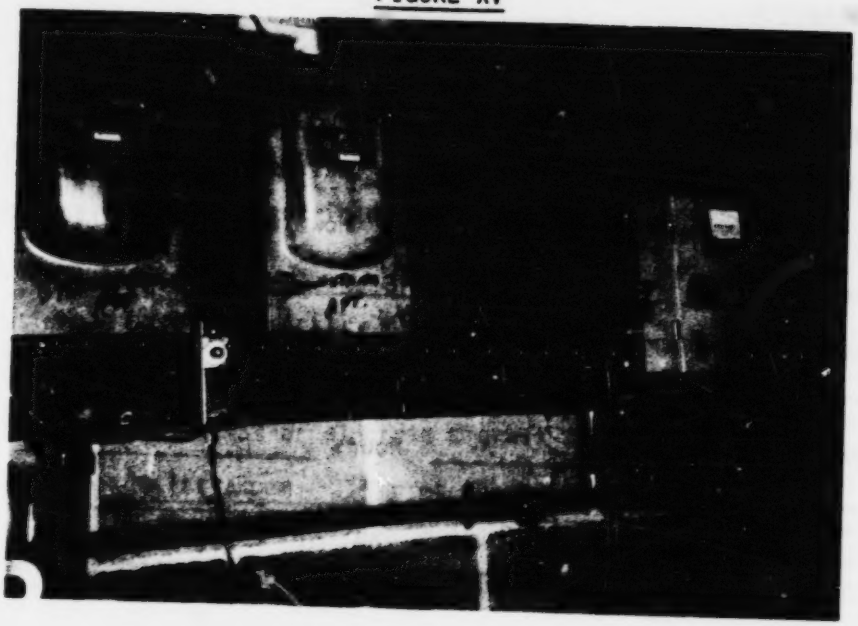
FIGURE XIV

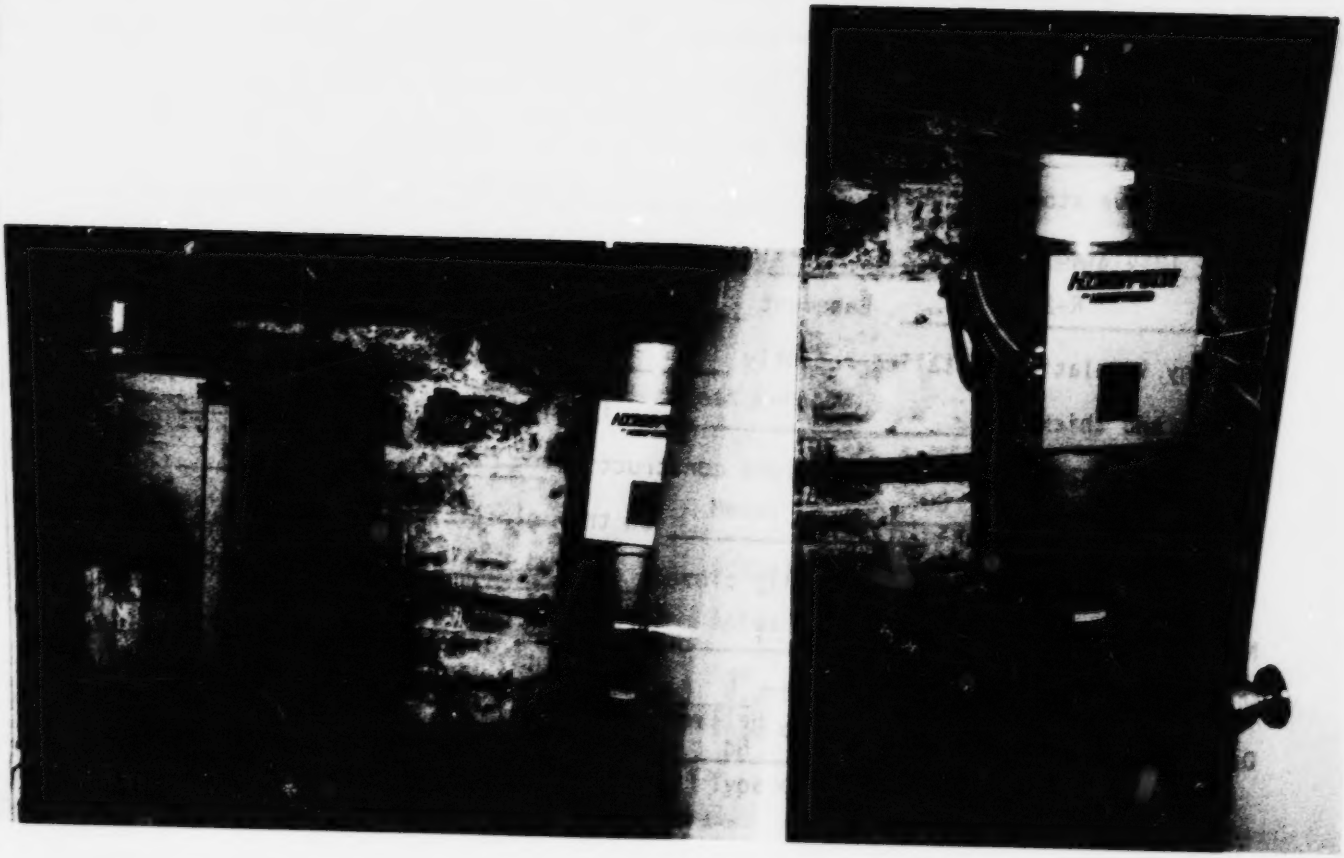


Oja Street, Naughton, Sudbury, Ont.

SEC. 4.3.

FIGURE XV





SEC. 4.4. HOMEOWNER QUESTIONNAIRE TABLE 4

GENERAL INFORMATION

Name of occupant Company Employee

Installation address 28 Oja Street, Naughton, Sudbury, Ontario

Single Family Residence? _____ Multiple? 2 Family - 2 Storey Duplex

Approx. age of structure 22 years How long have you resided? 16 years

No of occupants 11 Adults 6 How may are employed 3

If two or more, which hours _____

What indoor temperatures do you maintain:

While at work 21 - 22°C Hours All

Daytime 21 - 22°C Hours All

Nightime 21 - 22°C Hours All

STRUCTURE

Do you have a basement No Is it heated _____

Number of stories 2 storeys

Type of construction (Brick or Frame) Frame - siding

Does it have storm windows No Storm doors ½ yes, ½ no

Is it insulated yes Existing insulation R-value: Walls R-12,

Roof R-20, Basement R-12.

Was any insulation installed recently _____ If so, when _____,

Where, and thickness _____ Type _____

In your opinion, is building of tight construction Yes

No. of ~~basement~~ windows 15 Do they close tightly No

Is the door to the basement normally closed Yes, second storey

No of exhaust fans: Kitchen 1 Bathroom _____ Other _____

Where is thermostat located (room) L.R. (up) / Hallway (down) Inside or Outside wall inside

Does this house have a fireplace No Does it have a good damper N/A

....Cont'd.

P. 2

HOMEOWNER'S OUESTIONAIRE

SEC. 4.5.

APPLIANCES

Does this residence have a gas light No

Input or number of mantles _____

Does this residence have an electric or gas range Gas

If gas: Type Moffat Location Kitchen

Does this residence have a gas grill No

Hourly inputs _____ How often is it used _____

Does this residence have a gas or electric clothes dryer Gas

If gas: Location Utility Room Vented to outdoors? Yes

Size of vent pipe 10.16 Hourly input .424 M3

How often is it used Daily

Does this residence have a gas fired water heater No

Storage capacity _____ Hourly input _____

Size of flue pipe _____ Does this pipe connect to the same chimney as the heating system. _____

Does this residence have air conditioning No

Central _____ Window units _____ How many? _____

HEATING SYSTEM

Present Furnace.	Test Furnace.
Model 494013	Model 100
Actual Input 5.68 Litres/hr.	Actual Input 2.83 m^3
Actual Output 5.09 Litres/hr.	Actual Output 2.49 m^3
Age 22 years	Age 6 months
Type of Ignition Electro Spark	Type of Ignition Spark Plug
Type of Venting Chimney 20.32	Type of Venting Wall Vent 1.27 cm Condensating

TEST CHANGES:

INSTALLATION COSTS

1. Regular Installation Costs

a) Purchase of High Efficiency Units:

2 Forced Air Units @ $3,335.09 2 Pulse Boiler Units @ $4,265.00		$7,600.00

b) Installation:

Horner Gas Heating Service Ltd., North Bay Furnace	$500.00	
Prior's Plumbing and Heating, North Bay Boiler	700.00	
Perron's Plumbing and Heating, Sudbury Boiler	850.00	
Eddy's Heating, Thunder Bay Furnace	600.00	2,650.00
SUB-TOTAL		$10,250.09

2. Installation Costs due to Demonstration

Interconnecting Duct Work:

Horner Gas Heating Service Ltd., North Bay	$500.00	
Eddy's Heating, Thunder Bay	650.00	

Interconnecting Piping Set-Up:

Prior's Plumbing and Heating , North Bay	850.00	
Perron's Plumbing and Heating, Sudbury	1,000.00	$ 3,000.00

3. Monitoring

a) Equipment:

4 Event Counters	$106.57	
4 Elapsed Time Recorders	221.59	
2 Oil Meters	387.22	$ 715.38

b) Installation:

Horner Gas Heating Service Ltd., North Bay	$250.00	
Prior's Plumbing and Heating, North Bay	400.00	
Perron's Plumbing and Heating, Sudbury	450.00	
Eddy's Heating, Thunder Bay	250.00	$ 1,350.00
TOTAL		$15,315.47

SUMMARY OF INTERM COMMENTS

Due to the late installation and start-up of the test equipment during the 1981/82 heating season, it will be necessary to extend the test period through the 1982/83 heating season in order to obtain proper test results.

Both the furnaces have operated well over the test period, however, the test pulse combustion boilers at the Sudbury site and the North Bay (Jane St.) site have encountered several start-up and equipment difficulties. These difficulties finally resulted in the replacement of the valve assembly in the Sudbury unit and the noise problems required replacement of the complete boiler at the Jane Street location.

These problems have now been rectified and the boilers are now operating well.

Condensate samples were taken with the gas furnaces and boilers operating in a steady state condition. The analysis of the condensate are as follows:

Jane Street, North Bay	PH of 5.1
Pinewood Rd., North Bay	PH of 6.9
Broadway Ave., Thunder Bay	PH of 7.8
Oja Street, Sudbury	PH of 5.0

All final test results are expected to be submitted by the end of May, 1983 with the final report to follow.

POOR

QUALITY

ORIGINAL